Journal of the Indian Fisheries Association
25, 1995, (Proc.Nat.Symp. Aquacrops), 1-14

POPULATION DYNAMICS AND STOCK ASSESSMENT OF THE SPIDER PRAWN, *NEMATOPALAEMON TENUIPES* HENDERSON ALONG THE MAHARASHTRA COAST

VINAY D. DESHMUKH

Bombay Research Centre of Central Marine Fisheries Research Institute, Mumbai-400 001.

ABSTRACT

***Nematopalaemon tenuipes* is an important component of non-penaeid prawn resources of the northwest coast of India. During 1979-82 period it contributed 29.9% to the non-penaeid prawn and 5.6% to the total fish landings of Maharashtra. The von Bertalanffy growth parameter $L\infty$, K and t_o were 77.38 mm, 1.31 and -0.02 year for the males while for the females these parameters were respectively 87.23 mm, 1.30 and -0.01 year. The natural mortality coefficient (M) was 3.54 and 3.52 and the average total mortality coefficient (Z) during the period was 9.09 and 7.79 for the males and females respectively. With the exploitation rates of 0.61 and 0.55 for the males and females during the period, the total stock of the species was 26,270 tonnes and the standing stock was 3,418 tonnes. The maximum sustainable yield (MSY) of the species under the prevailing fishing conditions was 15,744 tonnes which is close to the average yield of 14,726 tonnes from the dol nets. Hence further increase in effort is not suggested.**

INTRODUCTION

The palaemonid prawn *Nematopalaemon tenuipes* is an important constituent of the non-penaeid prawn resources of the northwest coast of India. Although it forms a commercial fishery along both northwest and northeast coasts, the northern coast of Maharashtra, around Bombay, is particularly very rich. It is an important component of the dol net fishery of Maharashtra and occurs in enormous abundance, especially in April-May when entire prawn catch in dol nets is dominated by the species (Kunju, 1967).

Among the three major species of non-penaeid prawns occurring in Maharashtra, *N.tenuipes* is commercially the most important, having consumer demand in local markets, in both fresh as well as in dried form. Locally the species is called Ambad or Kardi.

Information on the fishery and biology of the species from Bombay coast is available from the work of

Shaikhmahamud and Tembe (1960), Kunju (1967, 1979) and Sukumaran (1983). Sukumaran (1982) also attempted total mortality estimates of the species from two important landing centres of Bombay. However, despite enormous abundance of the species, no attempt has been made to know about its stock in Maharashtra. The present investigation therefore relates to the population dynamics and stock assessment of *N.tenuipes* in Maharashtra waters during 1979-82 period.

MATERIAL AND METHODS

Data on catch and effort were collected for about 18 days in each month from two important dol net centres, viz. Versova, representing a centre from where boats operate dol nets in the open sea in the depth range of 10-40 m and Sassoon dock, representing an inshore centre where boats operate dol nets in the Bombay creek as well as in the open sea in the depth range of 5-25 m. Weekly samples of *N.tenuipes* were collected from both the centres for biology and length measurements in all the months excepting during monsoon months (i.e. June-September) at Versova where fishing operations are suspended due to inclement weather. The data obtained on each observation day were weighted to get the estimates for that day and the pooled days' estimates were weighted to get monthly estimates of effort, catch and the length compositions. The species composition data obtained at these centres were used to find out the total landing of the species in the state by apportioning the non-penaeid prawn catches of the state published by CMFRI (Srinath *et al.*, 1987).

Sexwise total lengths of prawns were taken from tip of the rostrum to the end of telson. The length data were grouped into 3 mm class intervals and midpoints of these classes were considered for estimation of growth by scatter diagram technique of Devaraj (1983). The parameters of von Bertalanffy growth equation were estimated by employing Ford-Walford graph (Walford, 1946). The length-weight relationship was calculated following Le Cren (1951).

The instantaneous rate of total mortality (Z) was estimated following the length converted catch curve method (Pauly, 1984). The natural mortality coefficient (M) was estimated using the method given by Cushing (1968). Exploitation rate (U) was estimated by the equation of Sekharan (1975) and the total annual stock (Y/U) and average standing stock (Y/F) were estimated by taking average annual catch of the species (Y) during 1979-82. The value of Y/F thus obtained was taken as the average biomass during the exploited phase of the species in the fishing grounds. The yield in weight per recruit was estimated from the equation of Beverton and Holt (1957). The maximum sustainable yield (MSY) was estimated by Corten's method (1974).

RESULTS

Fishery : Versova and Sassoon dock are the important landing centres representing both sea and inshore dol net fishery of the Maharashtra State. Annual catch of total fish, non-penacid prawns and *N.tenuipes* landed by the dol nets at these two centres together is shown in Fig.1. It is seen that during 1979-82 period, the catch of non-penacid prawns ranged from 4,644.8 t in 1980 to 5,578.5 t in 1979 while that of *N. tenuipes* showed declining trend from 1723.1 t in 1979 to 1201.1 t in 1982. During the period *N.tenuipes* contributed 9.03% to the total fish and 29.9% to the non-penacid prawns.

Annual catch of *N.tenuipes* for the state, estimated form the percentage contribution in non-penacid prawn landings is given in Table 1. It is seen that the catch of *N.tenuipes* ranged from 17,363 t in 1979 to 9,611 t in 1982 with the annual average catch of 14,725 t. The percentage contribution of the species was 5.6% in the total fish landed in the State.

Age and growth : For age and growth studies 7533 males in the size range 18-66 mm and 7342 females in the size range 16-76 mm from Sassoon dock and 4178 males and 4389 females in the size ranges 22-60 mm and 17-73 mm respectively from Versova were measured for length-frequency analysis during the period. Since sampling from Versova was discontinuous due to closure of the Fishery in monsoon months, the length data of two centres were pooled for the growth studies. The Scatter diagrams with monthly progression of modal values for males and females are shown by the growth curves in Fig. 2 & 3. The progressive lengths attained at monthly interval averaged for all the curves indicated that the males attain 37.08 mm, 56.39 mm, and 66.46 mm and the females attain 41.58 mm, 63.35 mm and 74.74 mm at the end of 6 months, one year and 1.5 years respectively. The growth rates for the two sexes are 4.7 mm/month for the males and 5.28 mm/month for the females during the first year of their life.

The average lengths attained at monthly interval were used for the Ford-Walford plot. The parameters, L_∞ and K were found to be respectively

Table 1 : *Estimated annual catch (in tonnes) of N.tenuipes and its percentage in non-penaeid prawns and total fish catch in Maharashtra.*

Year	Non-penaeid Prawns	*N.tenuipes*	%	Total fish	%
1979	56,208	17,363	30.9	293,326	5.6
1980	47,309	15,390	32.5	231,763	6.6
1981	52,855	16,538	31.3	272,587	6.1
1982	40,809	9,611	23.1	253,429	3.8
Average	49,295	14,725	29.9	262,776	5.6

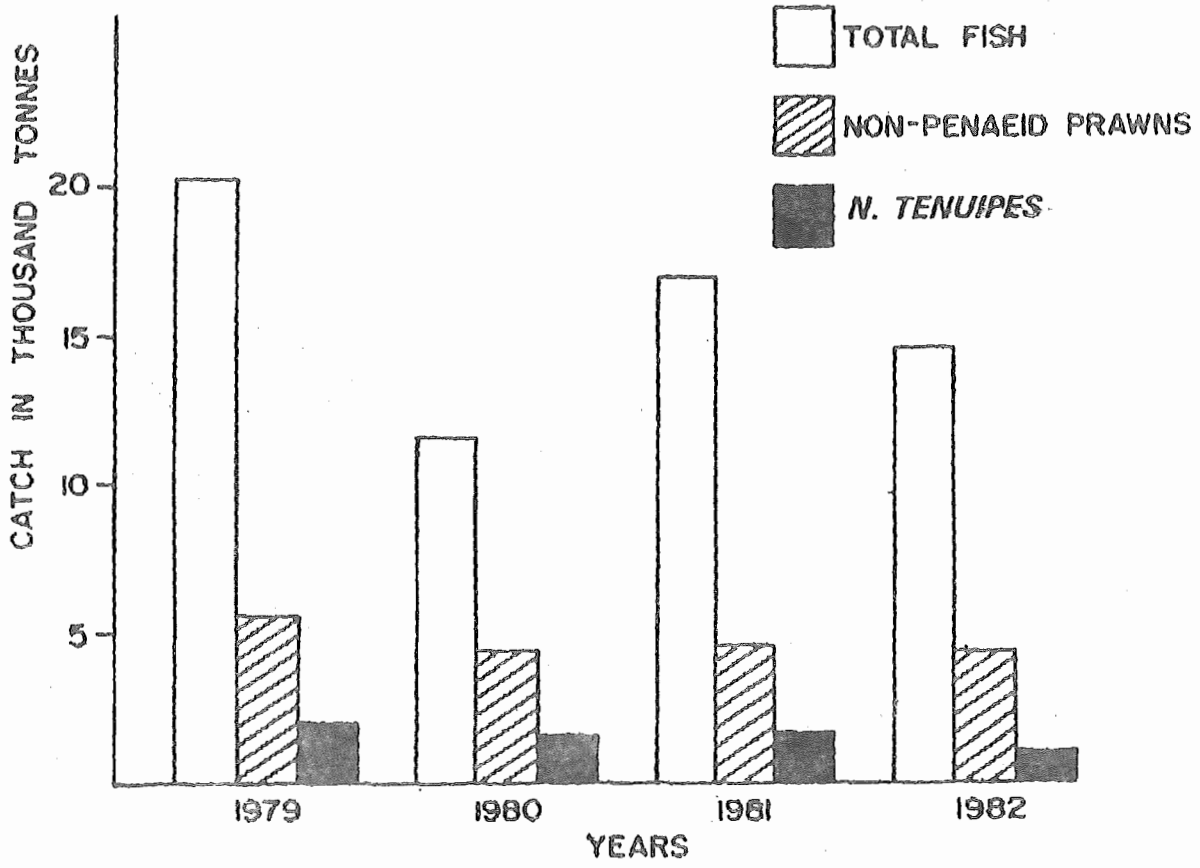

Fig. 1 : *Yearwise catch of N.tenuipes, non-penaeid prawns and total fish in dol nets at Versova and Sassoon dock during 1979-82.*

77.38 mm and 1.31 per year for the males and 87.23 mm and 1.30 per year for the females. The third parameter of von Bertalanffy growth equation, t_o estimated by employing modified expression of VBGF was -0.01 year for the males and -0.02 year for the females. The von Bertalanffy growth functions (VBGF) fitted for male and females were :

Male : $L_t = 77.38\ [1-\exp -1.31(t+0.01)]$

Female : $L_t = 87.23\ [1-\exp -1.30(t+0.02)]$

Length weight relationship : A total of 111 males and 159 females in the size range 22-55 mm and 20-64 mm respectively were analysed. The females included both ovigerous and non-ovigerous individuals. The relationship for the two sexes were :

$$W = 0.0000157\ L^{2.8323}$$

$$W = 0.000011\ L^{2.925}$$

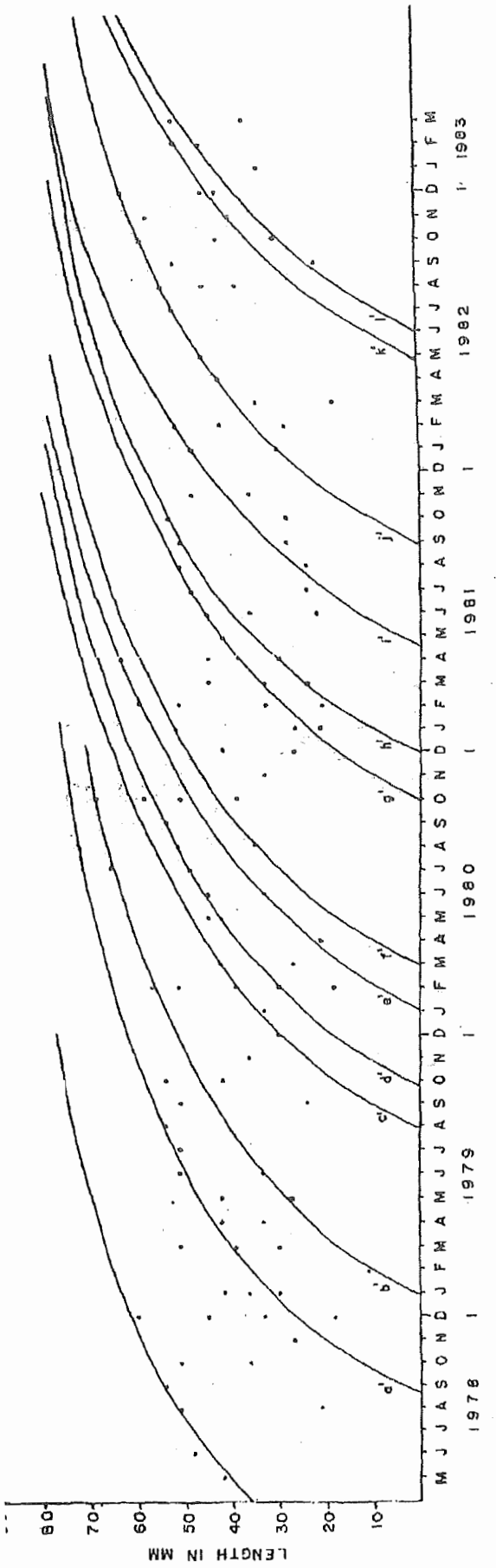

Fig. 2 : *Scatter diagram and growth curves for males of N.tenuipes.*

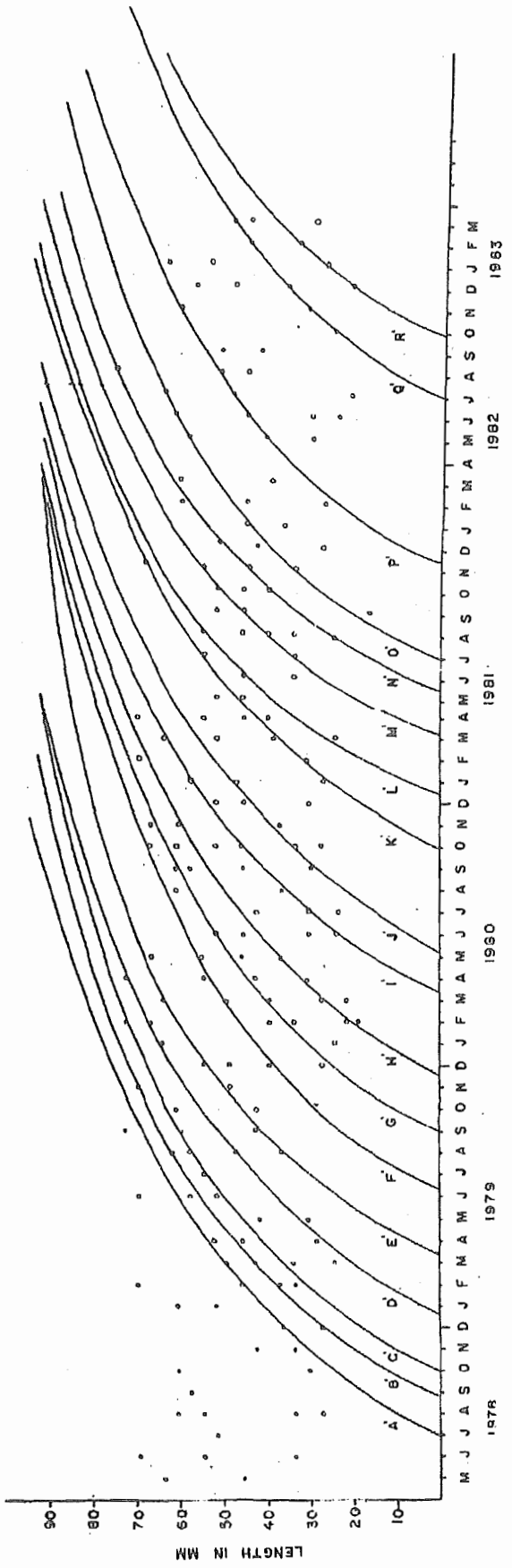

Fig. 3 : *Scatter diagram and growth curves for females of N.tenuipes*

Mortality rates :

The points that represent the straight descending part of the length-converted catch curve were taken into account to estimate the total mortality coefficient (Z). Figs. 4 and 5 show the estimation of total mortality coefficient of males and females for the years 1979-82. Since the relative age of the prawns was considered in months, the total mortality coefficients values are on the monthly basis. The total mortality of males on annual basis during the period ranged from 8.04 in 1979 to 10.93 in 1982 with an average of 9.09. In the case of females it ranged from 7.31 in 1979 to 9.12 in 1982 with the average of 7.79 (Table 2).

Natural mortality coefficient (M): The direct estimation of natural mortality coefficient by regression of 'Z' against fishing effort yielded negative values of 'M' which are unrealistic and therefore, an indirect method was followed. By employing Cushing's method (1968) the natural mortality coefficient for males and females is 3.54 and 3.52 respectively.

Fishing mortality coefficient (F): The estimates obtained by substracting natural mortality coefficient from the total mortality coefficients for 1979-82 period for the two sexes are given in Table 2.

Stock assessment :

Using length-weight relationship the monthly raised numbers of prawns in different size classes were weighted and added to obtain sex-wise annual catch of males and females for the period.

The sexwise estimates of exploitation rate, standing stock and the annual stock for the period are shown in Table 2. It is seen that with the average annual total mortality coefficient (Z) of 9.09 and fishing mortality coefficient (F) of 5.55, the exploitation rate for males was 0.605 and the annual and standing stocks were 9,547 t and 1,092 t respectively. Similarly for the females with average annual Z of 7.79 and F of 4.27 the exploitation rate was 0.55 and the annual and standing stocks were 16,733 t and 2,326 t respectively. With the total annual stock of 26,280 t and the annual production of 14,725 t the exploitation rate for the species was 0.56.

Maximum sustainable yield (MSY):

For fitting the yield per recruit model of Beverton and Holt (1957) the estimated weight asympotote, $W\infty$, for the males and females were 3.508 g and 5.222 g respectively. The smallest size of prawn observed in the catch was 12 mm hence the age at recruitment (tr) for the males was 0.1287 years and for the females 0.114 years. Since dol net is a non-selective gear, the age at first capture (tc) of exploited phase of population into fishery as calculated from the 50% cumulative size frequency upto fully represented size (first mode in annual size-frequency) was found to be 36 mm for both males

and females and hence their ages were 0.479 and 0.41 years respectively. The parameters used for the yield per recruit curves are given in Table 3 and the yield per recruit curves are given in Fig.6. The yield per recruit curve with M at 3.54 and tc at 0.479 years for males as a function of `F' showed that the Yw/R increased with increasing F and peaked at 0.1045 grammes. The corresponding F max values is 20.06. Similarly for the females with M at 3.52 and tc at 0.41 years the yield per recruit curve showed increase in Yw/R with increasing F and peaked at 0.1404 grammes with corresponding F max of 10.56. However, the average F values during 1979-82 were 5.55 and 4.27 and the corresponding Yw/R values were 0.09716 g and 0.1318 g for the males and females respectively. During the period the average annual yields were 5661 t and 9064 t for the two sexes respectively hence, using Corten's method (1974) the MSY for the males and females were 6089 t and 9655 t respectively. Thus MSY for the species in Maharashtra would be 15,744 tonnes.

DISCUSSION

Sukumaran (1982) estimated total mortality coefficient, Z, for *N. tenuipes* in Bombay waters for the period 1966-75 using Jackson's method (1939). He

Table 2 : *Stock assessment of N.tenuipes in Maharashtra during 1979-82.*

Year	Catch in tonnes Y	Z	M	F	Exploitation rate U	Total stock Y/U	Standing stock Y/F
Males :							
1979	6,173	8.04	3.54	4.50	0.56	11023	1372
1980	5,375	8.51	3.54	4.97	0.58	9267	1081
1981	8,054	8.89	3.54	5.35	0.60	13423	1505
1982	3,044	10.93	3.54	7.39	0.68	4476	412
Average	5,661	9.09	3.54	5.55	0.605	9547	1092
Females :							
1979	11,190	7.31	3.52	3.79	0.52	21,519	2953
1980	10,015	8.53	3.52	5.01	0.59	16,975	1999
1981	8,484	6.19	3.52	2.67	0.48	17,675	3178
1982	6,567	9.12	3.52	5.60	0.61	10,766	1173
Average	9,064	7.79	3.52	4.27	0.55	16,733	2326
Total	14,725	-	-	-	-	26,280	3418

presumed that males attain size of 40 and 58 mm and females 46 and 64 mm when they are 6 months and one year old respectively. Based on this age structure he considered that age groups between 7-12 months and 13 months and above are fully recruited. Thus dividing the age structure on half-yearly basis he estimated that the mean Z for the males was 3.68 for the Versova locality and 3.64 for Sassoon dock locality and for females 2.98 for the former and 3.11 for the latter. However, in his investigations Sukumaran (1982) did not consider the half-yearly period and hence these values appear lower when compared to the mean values of 9.09 and 7.79 observed during the present investigation. The estimates given by him would be however, comparable when these are considered on annual basis i.e.7.36 and 7.28 for the males and 5.96 and 6.22 for the females for Versova and Sassoon dock centres. Yet, these estimates are lower, perhaps due to lower fishing intensity during 1966-75 period as well as selection of Jackson's method (1939) which does not seem to be based on precise age and growth data. The length converted catch-curve method given by Pauly (1984) adopted in the present investigation, is based on shorter age intervals in which only relative age is considered and hence more realistic values of Z are obtained.

The natural mortality coefficient M estimated by Cushing's method (1968) for *N.tenuipes* is 3.54 for the males and 3.52 for the females. These value may appear on higher side. But *N. tenuipes* is a small sized prawn and it is predated upon by majority of pelagic as well as demersal fishes of the region (Deshmukh, 1988) hence these values of M would not be over-estimates. Ursin (1967) stated that the natural mortality of fishes is influenced by the environmental components such as activity of predators. Cushing (1968) remarked that the natural mortality also depends on the position of the

Table 3 : *Parameters of the yield per recruit model for N.tenuipes*

Parameters	Male	Female
Length asymptote $L\infty$	77.38 mm	87.23 mm
Weight asymptote $W\infty$	3.508 g	5.222 g
Growth coefficient K	1.31 (annual)	1.30 (annual)
t_o	-0.02 years	-0.01 years
Natural mortality coefficient M	3.54	3.52
Age at recruitment tr	0.1287 years	0.144 years
Age at first capture tc	0.479 years	0.410 years

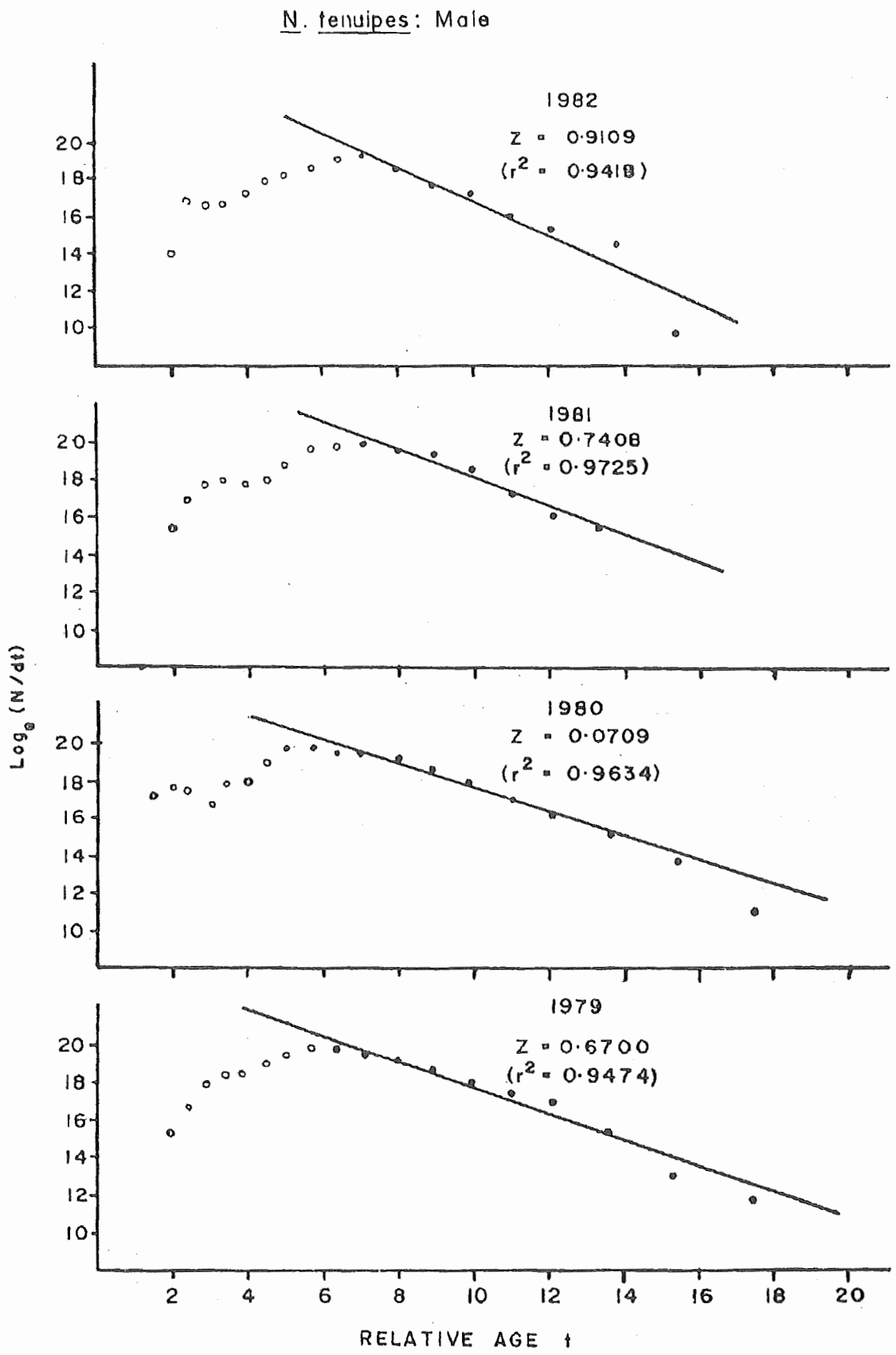

Fig. 4 : *Estimation of total mortality coefficient (Z) of males of N.tenuipes for 1979-82.*

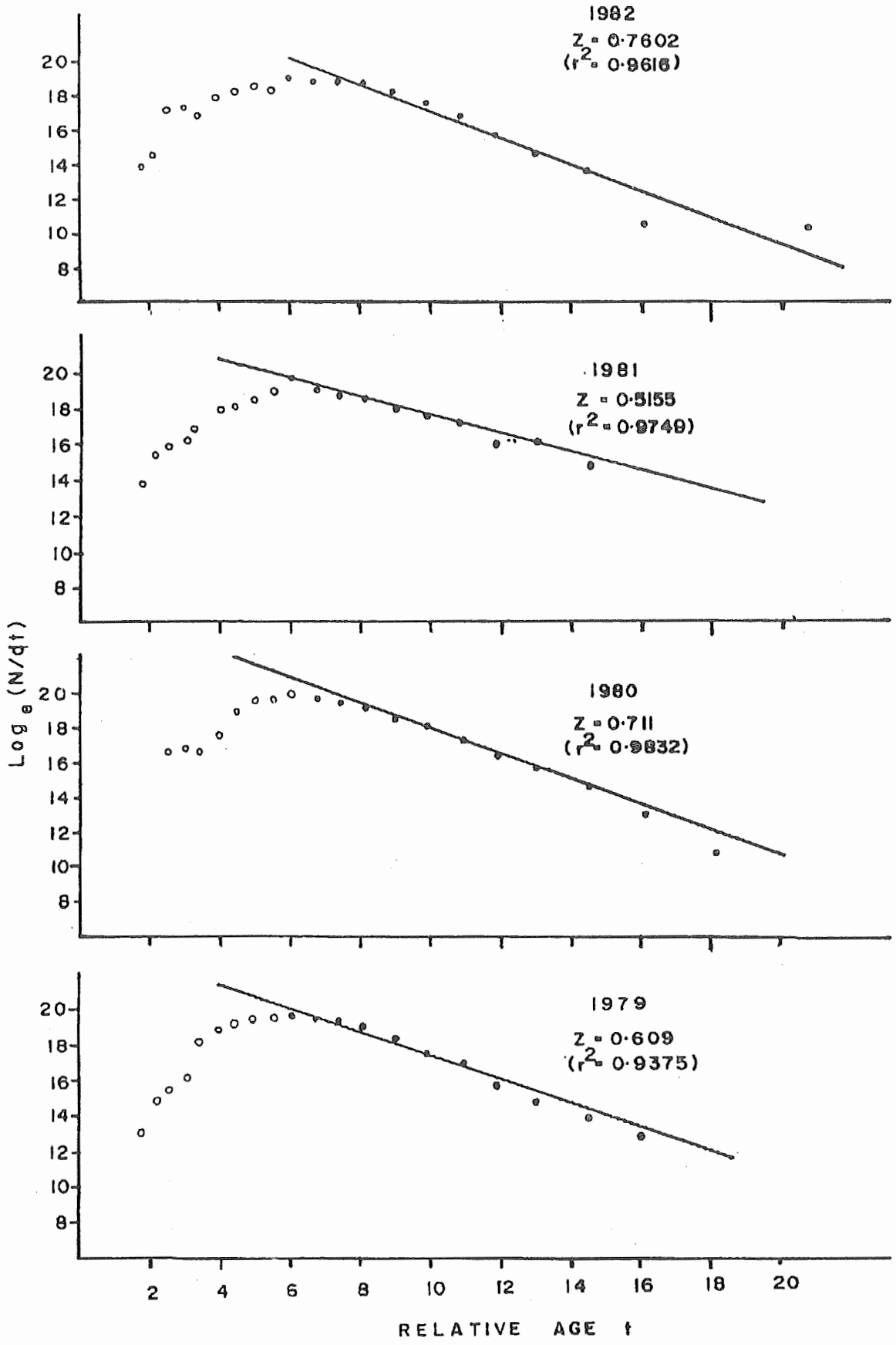

Fig. 5 : *Estimates of total mortality coefficient (Z) of females of N.tenuipes for 1979-82.*

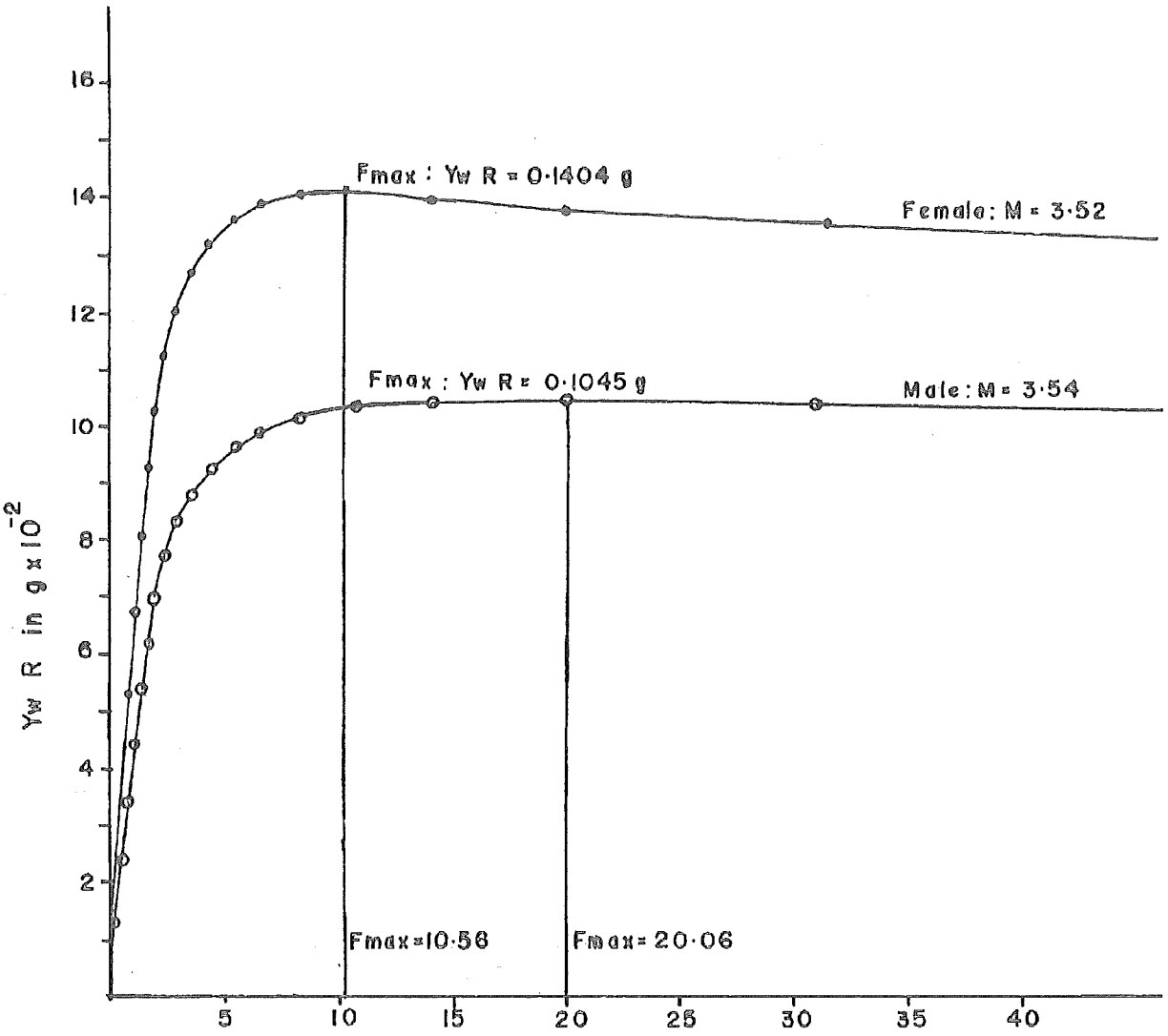

Fig. 6 : *Yield curves for males and femeles of N.tenuipes*

organism in the food chain. Since *N.tenuipes* is an intermediate organism in the trophic chain and highly predated up on by several fishes in the region (Deshmukh, 1988), the high natural mortality coefficient would be reasonable. Tiews (1978) has also stated that for the small sized caridean, *C.crangon,* the mortality due to predation is several times greater than by the fishing and Simpson *et al.,* (1970) remarked that the fishing mortality is not thought to be a major source of mortality in *Palaemon montangui.*

The shape of a yield per recruit curve is largely determined by the growth and natural mortality coefficients which has resulted in more or less flat topped yield per recruit curves. Such flat topped yield curves may suggest that there is little reduction in yield even at higher fishing intensity. It may further imply that the stock can sustain high fishing mortality without fear for over fishing. But under such circumstances species with high biotic potential could sustain the stock. Silas *et al.* (1984) suggested that prawns are annual stocks with

high natural mortality, therefore it would be advisable to fish them hard. This suggestion could be followed to some extent, in the case of penaeid prawns. They have very high fecundity coupled with multiple spawning and faster growth rate and hence have tremendous biotic potential (Etzold and Christmas, 1977). Garcia and Le Reste (1981) have remarked that recruitment of penaeid prawns is independant of the spawning stock and relatively few individuals left can replenish the stock. However, *N.tenuipes* is a caridean prawn with limited fecundity of 3000 eggs (Sukumaran, 1983) therefore, the species appears to have low biotic potential. Further, due to low biotic potential the recruitment of the stock would also depend on the spawning stock unlike the penaeid prawns. Obviously the stock of *N. tenuipes* has greater danger of being overfished to the extent of total depletion if the fishing intensity is increased indiscriminately as indicated by the flat topped Yw/R curves.

The maximum sustainable yield (MSY) of the species is 15,744 tonnes which is close to the average annual yield of 14,725 tonnes. In order to reach the MSY level, the fishing effort requires to be increased considerably. As it is always safer to be on the left of MSY, any further increase in fishing effort is not advisable.

ACKNOWLEDGEMENT

The author is thankful to Dr. P.V. Rao, Diretor, CMFRI and Dr. N.N. Pillai, Head Crustacean Fisheries Division for encouragement. Thanks are also due to Shri A.D. Sawant and A.Y. Mestry for the technical assistance.

REFERENCES

Beverton, R.J.H. and Holt S.J. 1957. On the dynamics of exploited fish populations. *Fish. Invest. Minist Agric. Fish.Food* G.B. Series II. **19**: 533 pp.

Corton, A. 1974. Recent changes in the stock of Celtic Sea herring *(Clupea harengus). J.cons.Perm. inst. Explor.Mar.* **35** : 194-201.

Cushing, D.H. 1968. *Fisheries biology: A Study in Population Dynamics.* Univ. of Wisconsin Press, Madison, Wisconsin. 200 pp.

Deshmukh, V.D. 1988. *A study of non-penaeid Prawns of Bombay.* Ph.D. thesis, University of Bombay. 458 pp.

Deshmukh, V.D. 1994. The non-penaeid prawn resources. *Mar. Fish. Infor. Serv. T & E Ser.,* No.130:5-8.

Devaraj, M. 1983. Fish Population Dynamics, Course Manual. *CIFE Bull.* No.3(10)83:98 pp.

Etzold, D.J. and Christmas, J.Y. 1977. A comprehensive summary of the shrimp fishery of the gulf of Mexico, United States - a regional management plan. *Tech. Pap. Ser. Gulf Coast Res. Lab.* **2** (2):20 pp.

Garcia, S. and Le Reste, L. 1981. Life

cycles, dynamics, exploitation and management of coastal penaeid shrimp stocks. *FAO Fish. Tech. pap.* No.203 : 215 pp.

Jackson, C.H.N. 1939. The analysis of an animal population. *J. Animal Ecol.* 8 : 238-246.

Kunju, M.M. 1967. Observations on the prawn fishery of the Maharashtra Coast. *Proc. Symp. Crustacea. Mar. Biol. Ass. of India.* Part IV : 1382-1397.

Kunju, M.M. 1979. Studies on the biology of *Nematopalaemon tenuipes* (Henderson) in Bombay coast. *Indian J. Fish.* **26** (1&2): 65-81.

Le Cren, E.D. 1951. Length-weight relationship and seasonal cycle in gonad weight and condition of the perch *(Perca fluviatilis) J.Anim. Ecol.* **20** : 201-219.

Pauly, D. 1984. Length-converted catch curves : A powerful tool for Fisheries Research in the tropics. Part II. *Fishbyte.* **2** (1) : 17-19.

Sekharan, K.V. 1975. Estimates of the stocks of oil sardine and mackerel in the present fishing off the West Coast of *India. Indian J.Fish.* **21** (1) : 177-182.

Shaikhmahmad, F.S. and Tembe, V.B. Study on Bombay prawns. The seasonal fluctuations and variations in abundance of the commercially important species of Bombay prawns with a brief not no their size, state of maturity and sex-ratio. *Indian J.Fish.* 7(1):69-81.

Silas, E.G., George, M.J. and Jacob, T. 1984. A review of shrimp fisheries of India : Scientific basis for the management of the resources. In: *Penaeid Shrimps - Their Biology and Management.* Ed. Gulland, J.A. and Rothschild, B. J., Fishing News Books Limited. 83-103.

Simpson, A.C., Howell, B.R. and Warren, P.J. 1970. Synopsis of biological date on the shrimp *Pandalus montangui* Leach, 1814. *FAO Fish. Rep.* **57** : 1225-1250.

Sukumaran, K.K., 1982. Estimates of mortality of *Nematopalaemon tenuipes* (Henderson) in the Bombay waters. *Indian J. Fish.* **29** (1&2) : 246-249.

Sukumaran, K.K. 1983. Some observations on the fishery and biology of *Nematopalaemon tenuipes* (Henderson) at Bombay. *Indian J. Fish.* **30 (2)** : 306-313.

Tiews, K. 1978. The predator - prey relationship between fish populations and the stock of brown shrimp *Crangon crangon* in German coastal waters). *Raap P.V.reun Cons. Int. Explor. Mer.* **172** : 250-258.

Ursin, E. 1967. A mathematical model of some aspects of fish growth, respiration and mortality. *J. Fish. Res. Bd. Can.* **24** : 2355-2453.

Walford, L.A. 1946. A new graphic method of describing the growth of animals. *Biol.Bull.Woods Hole.* **90**: 141-147.